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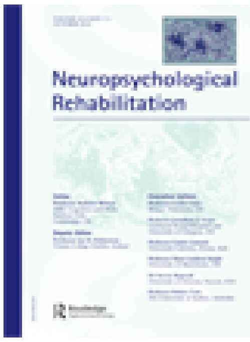

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Which approach to measure cognitive functioning should be preferred when exploring the association between cognitive functioning and participation after stroke?

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ABSTRACT
A variety of approaches are currently used to explore the relationship between cognitive functioning and participation after stroke. We aimed to gain insight into the preferred approach to measure cognitive functioning when exploring the association between cognitive functioning and participation in the long term after stroke. In this inception cohort study 128 individuals with stroke participated and were assessed at a single time point three to four years after the event. Participation was measured using the Restrictions subscale of the Utrecht Scale for Evaluation of Rehabilitation-Participation. Subjective cognitive complaints were assessed using the Cognition subscale of the Checklist for Cognitive and Emotional Consequences (CLCE-24-C). Objective cognitive performance was measured using the Montreal Cognitive Assessment (MoCA) and a neuropsychological test battery (NTB) testing multiple cognitive domains. Participation showed a strong correlation ($r = 0.51$) with the CLCE-24-C and moderate correlations with the domains of visuospatial perception ($r = 0.37$) and mental speed ($r = 0.36$). Backward linear regression analyses showed that participation restrictions were best explained by the combination of the CLCE-24-C and a test for visuospatial perception ($R^2 = 0.31$). Our findings suggest the use of a combination of subjective cognitive complaints and objective

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cognitive performance to explore the relationship between cognitive functioning and participation after stroke.

Abbreviations: BNT: Boston Naming Test; CLCE-24-C: Checklist for Cognitive and Emotional Consequences – Cognitive subscale: MoCA: Montreal Cognitive Assessment; NTB: Neuropsychological Test Battery; RBMT-D: Rivermead Behavioral Memory Test – Delayed recall; RBMT-I: Rivermead Behavioral Memory Test – Immediate recall; SDMT: Symbol Digits Modalities Test; TMT: Trail Making Test; USER-P-R: Utrecht Scale for Evaluation of Rehabilitation-Participation – Restrictions subscale; VOSP: Visual Object and Space Perception Test

Introduction

Stroke is one of the main causes of disability in the world (Collaborators GBDCoD, 2017). Due to the aging population and increased survival, more and more individuals with stroke have to deal with long-term restrictions in social and community participation (Kuhrij et al., 2018). According to the International Classification of Functioning, Disability and Health (ICF), participation has been defined as "the person's involvement in a life situation" and is regarded an important goal in stroke rehabilitation (World Health O, 2001). Depending on stroke characteristics, demographic factors and diagnostic criteria, the prevalence of cognitive deficits after stroke varies from 20–80% (Sun et al., 2014). Since cognitive functioning is an important determinant of participation in individuals with stroke, evaluation of cognitive functioning during follow-up assessments after stroke is essential to select potential rehabilitation interventions to improve participation (Barker-Collo et al., 2010; Ezekiel et al., 2018; Nijsse et al., 2017b). In the current stroke literature, various types of cognitive assessments are used to study the relationship between cognitive functioning and participation, measuring either objective or subjective cognitive functioning. It is largely unknown, however, which approach is preferable to study the association between cognitive functioning and restrictions in participation after stroke.

Objective cognitive performance can be assessed using cognitive screening instruments or standardized neuropsychological tests. Cognitive screening instruments, such as the Montreal Cognitive Assessment (MoCA), are often used in daily practice and can serve as a brief screening tool to detect global cognitive deficits (Nasreddine et al., 2005). MoCA scores have been associated with levels of activities after aneurysmal subarachnoid hemorrhage (Wong et al., 2014) and with return to work and participation in individuals aged under 70 years one year after stroke (de Graaf et al., 2018; van der Kemp et al., 2019). A neuropsychological test battery (NTB) is the "gold standard" to assess domain-specific cognitive deficits after stroke and can serve both diagnostic and prognostic purposes (Cumming et al., 2013). Verbal expression (Viscogliosi et al., 2011a), visuospatial perception (Beaudoin et al., 2013) and memory (Viscogliosi et al., 2011b) have been identified as cognitive domains negatively affecting participation after stroke. Additionally, attention and executive functioning were also found to predict levels of activities up to one year after stroke (Mole & Demeyere, 2018). The rationale behind the importance of these specific cognitive domains has not yet been fully elucidated (Cumming et al., 2014). A recent systematic review exploring the relationship between objective cognitive performance and long-term participation after stroke concluded that this relationship partially depends on the type of cognitive assessment undertaken (Mole & Demeyere, 2018). In general, NTBs have shown more consistent associations with participation after stroke than cognitive screening instruments (Mole & Demeyere, 2018). This may be explained by the limited sensitivity of the MoCA to assess essential cognitive domains, such as executive functioning (Chan et al., 2014).

However, the ecological validity of NTBs is weak (Ruff, 2003), and it is the subjective cognitive complaints in everyday life that matter most from the patients' perspective (Pollock et al., 2014). Subjective cognitive complaints can be measured using a self-report questionnaire, are highly prevalent after stroke and tend to increase over time (van Rijsbergen et al., 2015). Subjective cognitive complaints are related to both objective cognitive performance and long-term restrictions in participation after stroke, but do not necessarily coexist with deficits in objective cognitive performance (van Rijsbergen et al., 2014; van Rijsbergen et al., 2017). Although approximately half of the individuals with stroke who experience subjective cognitive complaints show evidence of deficits in objective cognitive performance (Lamb et al., 2013), the relationship between subjective cognitive complaints and objective cognitive performance is inconsistent (van Rijsbergen et al., 2014). The accumulation of deficits in multiple cognitive domains has been suggested to contribute to subjective cognitive complaints after stroke (van Rijsbergen et al., 2017).

In conclusion, cognitive functioning after stroke can be measured using screening instruments or an NTB to measure objective cognitive performance, or a self-report instrument to measure subjective cognitive complaints. The relationship between cognitive functioning and participation is inconsistent due to the variety of approaches used to measure cognitive functioning in the current stroke literature (Quinn et al., 2018). Therefore, the aim of this study was to gain insight into the preferred approach to measure cognitive functioning when exploring the association between cognitive functioning and participation in the long term after stroke. Both objective cognitive performance (global cognitive screening and an NTB) and subjective cognitive complaints were used to measure cognitive functioning. As we were solely interested in the bivariate relationship between cognitive functioning and participation, we did not take the effect of other determinants of participation after stroke into account. Our hypothesis is that a combination of objective cognitive performance and subjective cognitive complaints will provide the highest association with participation and would therefore be preferable when studying the relationship between cognitive functioning and participation after stroke.

Method

Design

The present study is a follow-up assessment (three to four years post-stroke) of the multicenter prospective longitudinal Restore4Stroke cohort study, in which individuals with stroke were followed for two years, including five measurements (van Mierlo et al., 2014).

Participants

Participants were consecutively recruited from stroke units in six participating hospitals in the Netherlands between March 2011 and March 2013. For the present study, participants were asked to participate in an additional assessment at three to four years post stroke. Individuals with stroke were eligible for Restore4stroke if they (1) had a clinically confirmed diagnosis of ischemic or hemorrhagic stroke; (2) gave informed consent within seven days after symptom onset; and (3) were at least 18 years old. Participants were excluded from the study if they (1) had a serious other condition that could interfere with study outcomes; (2) had been dependent in basic activities of daily living before the stroke occurred (defined by a Barthel Index score of ≤17 (Collin et al., 1988)); (3) had insufficient command of Dutch to complete the questionnaires and neuropsychological tests, based on clinical judgment; or (4) had suffered cognitive decline prior to the stroke (defined by a score of ≥1 on the Heteroanamnesis List Cognition [Meijer et al., 2006]). Participants who completed the Restriction subscale of the USER-Participation at three to four years after stroke were included in the analysis of the current study. Informed consent was obtained from all participants.

Procedure

Three to four years after stroke, a neuropsychological assessment, including a global cognitive screening, was conducted by a trained research assistant (graduated neuropsychologist), either in the nearest participating hospital or at the participants' home (if participants were not able to travel). Participants were also asked to complete a self-report questionnaire including measures of participation and subjective cognitive complaints. These measurements were conducted between July 2015 and October 2016. The Restore4Stroke cohort study and the additional follow-up measurements reported here were approved by the Medical Ethics Committees of all participating hospitals.

Dependent variables

The Restrictions subscale of the Utrecht Scale for Evaluation of Rehabilitation-Participation (USER-Participation) was used to measure participation (van der Zee et al., 2013b). The Restrictions subscale (USER-P-R) consists of 11 items, concerning difficulties experienced with vocational, leisure and social activities due to the stroke. For each item four response categories are available ("not possible," "with assistance," "with difficulty," and "without difficulty"). A "not applicable" option is available for all items in case an activity is not performed for other reasons or a restriction is not attributed to the stroke. The total score of the Restrictions subscale ranges from 0–100 and is based on items that are applicable. A higher score indicates a more favourable level of participation (fewer restrictions experienced). The USER-Participation has previously shown satisfactory validity and reliability (Post et al., 2012) and excellent responsiveness in individuals with stroke (van der Zee et al., 2011; van der Zee et al., 2013a).

Independent variables

Demographic factors

Information about gender, age, marital status and level of education was collected. Education levels were dichotomized into low (up to completed secondary vocational education) and high (completed higher secondary professional education or university) (Verhage, 1964).

Stroke-related factors

The hemisphere involved, the type of stroke (ischemic or hemorrhagic), history of stroke, length of stay in hospital and discharge destination were obtained from medical charts. The severity of stroke was assessed with the National Institutes of Health Stroke Scale four days after stroke (Brott et al., 1989). Activities of daily living were assessed by the stroke nurses with the Barthel Index four days after stroke (Collin et al., 1988).

Neuropsychological test battery

The Visual Object and Space Perception test (VOSP) (Warrington & James, 1991) assesses visuospatial perception abilities. The test consists of four subtests for object perception and four subtests for space perception, which can be used separately. The number of correct responses per subtest is scored, and if this number exceeds the minimal threshold, one point is given. The total score is calculated by adding up all points (which leads to a maximum score of 8).

The Boston Naming Test (BNT) (Kaplan, 1983) is a test of verbal expression. The short version was used, in which the participant is asked to name 29 items ranging in familiarity.

The Rivermead Behavioural Memory Test (RBMT) (Wilson et al., 1989) measures different aspects of memory. In one of the subscales the participant is read a story and asked to recall, both immediately (RBMT-I) and after a delay (RBMT-D), as many elements of the story as possible. The number of correctly recalled elements is scored.

The Symbol Digit Modalities Test (SDMT) (Smith, 1982) primarily assesses complex scanning and visual tracking. The test is mostly used to measure speed of information processing or mental speed. It consists of a sheet of paper with, at the top, a sequence of nine symbols and nine corresponding numbers (key). Within a 90-second time limit the participant is required, consulting the key as necessary, to insert the numbers associated with the symbols.

The Trail Making Test (TMT) (Reitan & Wolfson, 2004) is a test for visual attention, executive functioning and task switching/cognitive flexibility. This test requires speed of information processing, visual search strategies and visuomotor behaviour. The test has various parts (part A and part B), in which the participant is asked to connect numbers, letters or a combination of numbers and letters in the correct order. The time needed to complete part A and B is scored.

MoCA

The MoCA is a brief cognitive screening tool, which has been validated for individuals with stroke (Nasreddine et al., 2005). Scores range from 0–30 and higher scores indicate better cognitive functioning. Participants with <12 years of education were assigned one additional point on their MoCA score (Nasreddine et al., 2005). Cognitive impairment can be defined as MoCA<26, as this cut-off yields the best balance between sensitivity and specificity in detecting cognitive impairment (Nasreddine et al., 2005).

Subjective cognitive complaints

The presence of subjective cognitive complaints was assessed using the Cognition subscale of the Checklist for Cognitive and Emotional Consequences (CLCE-24-C), which consists of 13 items (e.g., problems with "doing two things at once" or "remembering new information") (Rasquin et al., 2006). The items involve multiple cognitive domains (including executive functioning, attention, memory, speed of processing and visuospatial perception) and are indicative of the cognitive complaints the patient experiences. The interviewer scores a "0" for the absence of complaints, a "1" for possible complaints and a "2" for the presence of complaints. Total scores range from 0-26 and higher scores indicate more cognitive complaints. The CLCE-24 is a feasible and valid instrument to use in individuals with stroke (van Heugten et al., 2007).

Statistical analysis

All analyses were conducted with SPSS statistics version 24 (IBM, Armonk, NY). Descriptive statistics were used to describe participant characteristics and dependent variables. Baseline characteristics of participants lost to attrition and study participants were compared using independent T-tests (continuous variables) and Chi-square tests (categorical variables).

Raw scores of the RBMT-I, RBMT-D, SDMT and TMT were converted to *t*-scores using age-specific (and, when available, education- and gender-specific) normative data. The TMT t-score is based on the raw scores of TMT part B, adjusted for the raw scores on TMT part A. Scores on the BNT were converted to percentiles using age- and education-specific normative data. Scores on the VOSP were adjusted for age (Warrington & James, 1991).

Bivariate associations of the NTB (BNT, RBMT-I, RBMT-D, SDMT, TMT and VOSP), MoCA and CLCE-24-C with the USER-P-R were tested using Spearman correlations. As proposed by Cohen, correlation coefficients of the order of 0.10 were interpreted as "weak," those of 0.30 as "moderate" and those of 0.50 or higher as "strong" (Cohen, 1988). Bonferroni correction was used to account for multiple comparisons, and $p < 0.001$ was considered statistically significant.

Multiple linear regression analysis was used to explore the association between different combinations of cognitive measures and participation three to four years after stroke. The USER-P-R was entered as a dependent variable in all models. The models were built using a hierarchical approach. The NTB, currently regarded as a "gold standard" to assess cognitive functioning, was entered in model 1. As we were interested in the association between participation and a combination of objective cognitive performance (MoCA and NTB) and subjective cognitive complaints (CLCE-24-C), we entered the MoCA and CLCE-24-C in model 2 and the NTB and CLCE-24-C in model 3. In order to explore which combination of approaches is preferable when exploring the relationship between cognitive functioning and participation, backward selection was used to fit the best model of cognitive measures (out of the NTB, MoCA and CLCE-24-C) in model 4. Possible multicollinearity was checked (VIF < 4), which did not reveal any problems. A value of $p < 0.05$ was considered statistically significant.

Results

A total of 395 participants were included in the Restore4Stroke study within the first week after stroke onset, and 160 of them (40.5%) were tested three to four years after stroke. The Restrictions subscale of the USER-P was completed by 128 participants (80.0%) at three to four years after stroke, and they were included in the analysis. Of the 235 resigned participants, 33 had died, 120 refused further participation, 47 were lost to follow-up and 35 were lost to attrition because of an insufficient general physical condition.

Participant characteristics are presented in Table 1. The study participants were significantly younger at stroke onset and were less cognitively impaired than the participants lost to attrition. The participation and cognitive test scores at three to four years after stroke are presented in Table 2. The CLCE-24-C showed adequate internal consistency (Cronbach's $\alpha = 0.79$). The majority of participants (89.0%) reported subjective cognitive complaints for at least one item of the CLCE-24-C. According to the MoCA, almost half (45.3%) of participants were cognitively impaired at three to four years after stroke. Cognitive domains most often affected according to the NTB were immediate and delayed recall (49.1% and 25.2% respectively), higher visual perception (20.0%) and mental speed (15.3%).

Bivariate analyses

CLCE-24-C scores were strongly correlated with participation scores three to four years after stroke ($r = 0.51$), as shown in Table 3. MoCA ($r = 0.24$) and NTB scores correlated weakly with participation, except for the SDMT ($r = 0.36$) and VOSP scores ($r = 0.37$) which showed a moderate correlation with participation. CLCE-24-C scores showed weak negative correlations with the MoCA and NTB. Weak (BNT, TMT and VOSP) or moderate (RBMT-I, RBMT-D and SDMT) positive correlations were observed between the MoCA and the NTB. Except for the

Table 1. Participant characteristics ($n = 395$).

	Study participants ($n = 128$)	Drop-outs ($n = 267$)	p values[b]
Demographic factors			
Sex (% male)	68.8	62.9	0.256
Age in years (at time of stroke)	63.7 ± 11.0	68.1 ± 13.1	0.001*
Marital status (% living together)	73.4	66.3	0.152
High education level (%)[a]	28.1	25.8	0.624
Stroke-related factors			
Ischemic stroke (%)	92.1	94.0	0.275
Stroke location			
Left hemisphere (%)	33.9	43.1	0.165
Right hemisphere (%)	44.9	41.2	
Vertebrobasilar stroke (%)	21.3	15.7	
First stroke (%)	85.2	89.5	0.211
Discharge home after hospital stay (%)	75.8	67.8	0.104
Severity of stroke	2.7 ± 3.1	2.8 ± 3.3	0.647
No stroke symptoms (% NIHSS 0)	24.2	23.6	0.612
Minor stroke symptoms (% NIHSS 1-4)	57.0	55.4	
Moderate stroke symptoms (% NIHSS 5-12)	17.2	18.4	
Severe stroke symptoms (% NIHSS ≥ 13)	1.6	2.6	
ADL 4 days after stroke	17.1 ± 4.6	16.7 ± 4.9	0.382
% ADL-dependent (BI ≤17)	31.3	34.5	0.527
Cognitive functioning 2 months after stroke			
Cognitive functioning (MoCA)	24.5 ± 3.6	23.0 ± 4.1	0.001*
% cognitively impaired (MoCA ≤ 25)	58.2	72.4	0.007*

Note. Values are percentages or mean ± SD.
ADL, activities of daily living; BI, Barthel Index; MoCA, Montreal Cognitive Assessment; NIHSS, National Institutes of Health Stroke Scale.
[a]Completed University of Professional Education and higher.
[b]Comparison between "study participants" and "drop-outs".
*p values are significant ($p < 0.05$).

Table 2. Scores on participation and cognitive tests (MoCA, CLCE-24-C and NTB) at three to four years after stroke.

			n	Mean (±SD)	Range	% impaired
USER-*P*-R			128	83.55 (±19.72)	13–100	
SCC	CLCE-24-C		127	7.28 (±5.53)	0–23	89.0[b]
OCP	MoCA		124	24.96 (±3.18)	15–30	45.3[c]
	NTB	BNT[a]	118	45.71 (±32.61)	5–100	2.5[d]
		RBMT-I[a]	112	36.14 (±8.91)	20–68	49.1[d]
		RBMT-D[a]	111	40.67 (±9.13)	23–80	25.2[d]
		SDMT[a]	111	46.67 (±10.92)	17–71	15.3[d]
		TMT[a]	106	51.01 (±9.81)	29–86	4.7[d]
		VOSP	75	6.72 (±0.75)	3–8	20.0[e]

Abbreviations: BNT, Boston Naming Test; CLCE-24-C, Checklist for Cognitive and Emotional Consequences – cognitive subscale; MoCA, Montreal Cognitive Assessment; NTB, Neuropsychological Test Battery; OCP, objective cognitive performance; RBMT-D, Rivermead Behavioral Memory Test – Delayed recall; RBMT-I, Rivermead Behavioral Memory Test – Immediate recall; SCC, subjective cognitive complaints; SD, standard deviation; SDMT, Symbol Digits Modalities Test; TMT, Trail Making Test; USER-*P*-R, Utrecht Scale for Evaluation of Rehabilitation-Participation Restrictions subscale; VOSP, Visual Object and Space Perception Test.
[a]*t*-scores, using age-matched (and, when available, education and gender) normative data.
[b]Impairment defined as reported subjective cognitive complaints in at least one item of the CLCE-24-C.
[c]Impairment defined as MoCA scores < 26.
[d]Impairment defined as scores < 1.5 SD below the mean.
[e]Impairment defined as VOSP scores < 7.

very strong correlation between RBMT-I and RBMT-D ($r = 0.83$), inter-correlations between NTB test scores were weak to moderate. The CLCE-24-C ($R^2 = 0.19$), VOSP ($R^2 = 0.18$), SDMT ($R^2 = 0.15$) and MoCA ($R^2 = 0.06$) explained the largest amount of variance in participation scores three to four years after stroke.

Multivariate linear regression

Results of the multivariate regression analyses are shown in Table 4. In model 1 (including NTB) higher scores on the SDMT and VOSP were associated with fewer restrictions in participation three to four years after stroke. In model 2 (including MoCA and CLCE-24-C), only having fewer cognitive complaints was associated

Table 3. Bivariate analyses: correlations between the neuropsychological tests, MoCA, CLCE-24-C and participation (*n* = 128) at three to four years after stroke.

			CLCE-24-C	MoCA	BNT	RBMT-I	RBMT-D	SDMT	TMT	VOSP
USER-*P*-R			−.51*	.24*	−.04	.14	.11	.36*	.20	.37*
SCC:	CLCE-24-C			−.27*	−0.08	−.25*	−.22	−.32*	−.26*	−.27
OCP:	MoCA				.07	.35*	.39*	.37*	.24	.26
	NTB:	BNT				.22*	.21	.16	.15	.06
		RBMT-I					.83*	.29*	.13	.10
		RBMT-D						.30*	.14	.15
		SDMT							.40*	.32*
		TMT								.29

Abbreviations: BNT, Boston Naming Test; CLCE-24-C, Checklist for Cognitive and Emotional Consequences – cognitive subscale; MoCA, Montreal Cognitive Assessment; NTB, Neuropsychological Test Battery; RBMT-D, Rivermead Behavioral Memory Test – Delayed recall; RBMT-I, Rivermead Behavioral Memory Test – Immediate recall; SDMT, Symbol Digits Modalities Test; TMT, Trail Making Test; USER-*P*-R, Utrecht Scale for Evaluation of Rehabilitation-Participation Restrictions subscale; USER-*P*-S, Utrecht Scale for Evaluation of Rehabilitation-Participation Satisfaction subscale; VOSP, Visual Object and Space Perception Test.
*$p < .05$.

with fewer restrictions in participation three to four years after stroke. In both model 3 (combining NTB and CLCE-24-C) and model 4 (using backward selection), fewer cognitive complaints and a higher score on the VOSP were associated with fewer restrictions in participation three to four years after stroke. Combining the CLCE-24-C and the VOSP in model 4 ($R^2 = 0.31$) explained a larger amount of variance in participation scores three to four years after stroke than the NTB in model 1 ($R^2 = 0.20$), combining the CLCE-24-C and the MoCA in model 2 ($R^2 = 0.20$) or the CLCE-24-C and the NTB in model 3 ($R^2 = 0.29$).

Discussion

The aim of this study was to gain insight into the preferred approach to measure cognitive functioning when exploring the association between cognitive functioning and participation in the long term after stroke. Although significant relationships were found between all cognitive measures and participation after stroke, the subjective CLCE-24-C score showed the strongest bivariate association with participation after stroke (19% explained variance). Among the NTB tests, the domains of visuospatial perception (VOSP) and mental speed (SDMT) were moderately associated with participation after stroke. Global cognitive screening (MoCA) showed a weak association with participation after stroke. The combination of the CLCE-24-C and VOSP explained the highest proportion (31%) of the variance in participation scores. Therefore, a combination of subjective and objective measures (preferably including the cognitive domains of visuospatial perception and mental speed) is to be recommended when exploring the association between cognitive functioning and participation after stroke.

Subjective cognitive complaints

The high prevalence of subjective cognitive complaints three to four years after stroke found in this study (89.0%) is in accordance with previous studies (van Rijsbergen et al., 2014). The strong association between subjective cognitive complaints and participation after stroke is a relatively new finding. One cross-sectional study concerned individuals who had been discharged home and were assessed at least 6 months post-stroke. It showed a weak association between subjective cognitive complaints and difficulties of community reintegration ($r = -0.23$) (Kimonides et al., 2018). In another study, subjective cognitive complaints were among the main predictors of participation restrictions in individuals six months after an aneurysmal subarachnoid hemorrhage (Huenges Wajer et al., 2017). A possible explanation could be the similarity between the CLCE-24-C and USER-P. Both instruments are self-reported questionnaires asking about complaints/restrictions experienced in everyday life, whereas NTB and MoCA may lack ecological validity and may less accurately reflect daily life functioning (Ruff, 2003).

Table 4. Multivariate analysis: associations between different combinations of cognitive measures (CLCE-24-C, MoCA and NTB) and participation three to four years after stroke.

			Model 1 ($n = 75$)			Model 2 ($n = 124$)			Model 3 ($n = 75$)			Model 4 ($n = 75$)		
			NTB			MoCA and CLCE-24-C			NTB and CLCE-24-C			Backward model		
			B	(95% CI)	β	B	(95% CI)	β	B	(95% CI)	β	B	(95% CI)	β
		Constant	−0.12	(−42.74–42.49)		74.56	(46.71–102.41)		25.11	(−18.41–68.64)		28.39	(−8.75–65.54)	
SCC:	CLCE-24-C					−1.46	(−2.06–−0.86)	−0.41*	−1.18	(−1.96–−0.40)	−0.33*	−1.35	(−2.07–−0.64)	−0.38*
OCP:	MoCA					0.79	(−0.26–1.83)	0.13				[a]		
	NTB:	BNT	−0.06	(−0.20–0.07)	−0.10				−0.05	(−0.18–0.08)	−0.09	[a]		
		RBMT-I	0.31	(−0.70–1.32)	0.14				0.11	(−0.85–1.07)	0.05	[a]		
		RBMT-D	−0.13	(−1.11–0.84)	−0.06				−0.05	(−0.97–0.88)	−0.02	[a]		
		SDMT	0.47	(0.01–0.92)	0.26*				0.32	(−0.12–0.76)	0.18	[a]		
		TMT	0.05	(−0.42–0.52)	0.03				−0.03	(−0.47–0.42)	−0.01	[a]		
		VOSP	8.39	(2.18–14.60)	0.32*				7.99	(2.12–13.85)	0.30*	9.67	(4.37–14.97)	0.37*
		R^2	0.20			0.20			0.29			0.31		

Abbreviations: 95% CI, 95% confidence interval; B, unstandardized regression coefficient; β, standardized regression coefficient; BNT, Boston Naming Test; CLCE-24-C, Checklist for Cognitive and Emotional Consequences - cognitive subscale; MoCA, Montreal Cognitive Assessment; NTB, Neuropsychological Test Battery; OCP, objective cognitive performance; RBMT-D, Rivermead Behavioral Memory Test – Delayed recall; RBMT-I, RBMT - Immediate recall; SCC, subjective cognitive complaints; SDMT, Symbol Digits Modalities Test; TMT, Trail Making Test; USER-P-R, Utrecht Scale for Evaluation of Rehabilitation-Participation Restrictions subscale; VOSP, Visual Object and Space Perception Test.

[a] Variable removed in final backward analysis.

*$p < .05$.

Our study showed a weak correlation between subjective cognitive complaints and objective cognitive performance. Although some studies found associations between cognitive screening instruments (including the MoCA in one study (Nijsse et al., 2017a)) and subjective cognitive complaints (Narasimhalu et al., 2013; van Heugten et al., 2007; Xiong et al., 2011), other studies did not find a relationship between subjective cognitive complaints and NTB tests (Aben et al., 2011; Duits et al., 2008; Winkens et al., 2009). This inconsistency may be explained by the limited ecological validity of the NTB tests used in some studies (van Rijsbergen et al., 2017) and by the huge variation of NTB tests across studies. Also, it has been suggested that the accumulation of cognitive deficits in various cognitive domains contributes to subjective cognitive complaints after stroke, explaining the lack of correlation between individual NTB tests and subjective cognitive complaints (van Rijsbergen et al., 2017). However, the MoCA, a global cognitive screening instrument covering multiple domains, also weakly correlated with subjective cognitive complaints in our study ($r = 0.27$).

Objective cognitive performance

The cognitive domains of visuospatial perception (VOSP) and mental speed (SDMT) showed the strongest correlation with participation after stroke ($r =$ 0.37 and 0.36 respectively), and were also associated to participation in the multivariate models (SDMT only in model 1, VOSP in all models). Previous studies identified the same cognitive domains as determinants of quality of life up to one year after stroke (Cumming et al., 2014). It has been suggested that visuospatial perception is a more fundamental aspect of cognitive functioning, upon which other cognitive domains depend, and that this is a prerequisite for daily life functioning (Cumming et al., 2014). Impairments in executive functioning and mental speed may affect the ability to plan, monitor and evaluate more complex daily tasks, having a negative impact on daily life functioning (Mole & Demeyere, 2018).

In the final multivariate model (model 4 using backward selection) the combination of the visuospatial perception (VOSP) domain and subjective cognitive complaints (CLCE-24-C) provided the strongest association with participation. Previous studies also found an association between visuospatial perception and participation up to 6–12 months after stroke (Beaudoin et al., 2013; Desrosiers et al., 2008; Viscogliosi et al., 2011b). According to a recent systematic review looking into the relationship between cognitive functioning and participation after stroke, cognitive screening instruments such as the MoCA show less consistent associations with participation than NTBs (Mole & Demeyere, 2018). Our results confirm the suggestion that specific cognitive domains are more strongly associated with participation than global cognitive functioning (Barker-Collo & Feigin, 2006), as the MoCA showed a weak correlation and no association with participation after stroke in the multivariate models.

Limitations

Due to the relatively long period that elapsed between the follow-up assessments, a considerable number of participants were lost to follow-up. It could be that only the most motivated participants were willing to participate in an additional assessment. This may have led to selection bias, as the study sample was significantly younger at stroke onset and was less cognitively impaired compared to the resigned participants. This could therefore negatively affect the generalizability of the results to older individuals with stroke and those with severe cognitive impairments. However, current epidemiological studies show that most people have relatively mild strokes. Furthermore, missing NTB data (especially the VOSP) considerably reduced the sample size ($n = 75$) in the multivariate models (models 1, 3 and 4). However, apart from cognitive functioning (participants with missing NTB data being more cognitively impaired based on the MoCA), no significant differences in any of the baseline characteristics were observed between the multivariate model sample ($n = 75$) and the participants at stroke onset ($n = 395$) or at 3–4 years after stroke ($n = 128$). Lastly, although we aimed to cover the most important cognitive domains after stroke, not all aspects of cognitive functioning are represented in the NTB (e.g., planning, visual memory and social cognition are lacking).

Conclusions

This study has shown the impact of subjective cognitive complaints on everyday life in the long term after stroke, as subjective cognitive complaints were strongly related to restrictions in participation three to four years after stroke. A combination of objective cognitive performance (preferably including the domains of visuospatial perception and mental speed) and subjective cognitive complaints showed the strongest association with participation, and is therefore to be recommended when exploring cognitive functioning as a determinant of participation after stroke. External validation in another stroke sample is needed to confirm whether these results also apply to older individuals with stroke and those with severe cognitive impairments due to the limited generalizability to these patient categories in our study population. Last but not least, since participation is an important goal in rehabilitation, it is important to consider subjective cognitive complaints in stroke aftercare.

Disclosure statement

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